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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 09/192,674 | 11/16/1998 | DANIELE BAGNI | PHN-16.762 | 1092 |

7590 11/04/2002

Corporate Patent Counsel
U.S. Philips Corporation
580 White Plains Road
Tarrytown, NY 10591

| EXAMINER | |
|---|---|
| CHEN, WENPENG | |
| **ART UNIT** | **PAPER NUMBER** |
| 2624 | 24 |

DATE MAILED: 11/04/2002

Please find below and/or attached an Office communication concerning this application or proceeding.

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**BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES**

Paper No. 24

Application Number: 09/192,674
Filing Date: November 16, 1998
Appellant(s): BAGNI ET AL.

mailed
~~RECEIVED~~

NOV 0 4 2002

Technology Center 2600

Russell Gross
For Appellant

**EXAMINER'S ANSWER**

This is in response to the appeal brief filed on August 19, 2002.

***(1) Real Party in Interest***

A statement identifying the real party in interest is contained in the brief.

***(2) Related Appeals and Interferences***

A statement identifying the related appeals and interferences which will directly affect or be directly affected by or have a bearing on the decision in the pending appeal is contained in the brief.

***(3) Status of Claims***

The statement of the status of the claims contained in the brief is correct.

***(4) Status of Amendments After Final***

The appellant's statement of the status of amendments after final rejection contained in the brief is correct.

***(5) Summary of Invention***

The summary of invention contained in the brief is correct.

***(6) Issues***

The appellant's statement of the issues in the brief is correct.

***(7) Grouping of Claims***

The rejection of claims 1-9 stand or fall together because appellant's brief does not include a statement that this grouping of claims does not stand or fall together and reasons in support thereof. See 37 CFR 1.192(c)(7).

***(8) Claims Appealed***

The copy of the appealed claims contained in the Appendix to the brief is correct.

*(9) Prior Art of Record*

| | | |
|---|---|---|
| 5,146,325 | NG | 9-1992 |

de Haan, G et al., "True-Motion Estimation with 3-D Recursive Search Block Matching," IEEE Trans. on Circuits and Systems for Video Technology, vol. 3, no. 5 (October 1993), pp. 368-379

*(10) Grounds of Rejection*

The following ground(s) of rejection are applicable to the appealed claims:

Claims 1-9 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ng (US patent 5,146,325) in view of de Haan et al. ("True-Motion Estimation with 3-D Recursive Search Block Matching," de Haan, G et al., IEEE Trans. On Circuits and Systems for Video Technology, vol. 3, No. 5, October 1993, pages 368-379.)

Ng teaches a device and method for coding and decoding comprising the following means and corresponding steps for:

-- estimating (ME) first motion vectors (MV c, MV l, MV r, MV a, MV b) for first objects (16*16) of a large size; (column 5, lines 39-64)

-- generating prediction errors in dependent on the motion vectors associated with the second objects (8*8) being smaller than the first objects; (column 5, lines 39-64; The residues are the prediction errors.)

-- combining (VLC) the first motion vectors and the prediction errors; (column 7, lines 44-61)

-- generating ($VCL^{-1}$) first motion vectors (MV c, MV l, MV r, MV a, MV b) and prediction errors from input stream, the first motion vectors (MV c, MV l, MV r, MV a, MV b)

relating to the first objects of a large size; (elements 306 and 308 of Fig.5; column 10, line 62 to column 11, line 23)

-- generating an output signal in dependence on the prediction errors and the motion vectors associated with the second objects; (column 10, lines 31-61; )

-- means for receiving a motion-compensated, predictively-encoded image signal; (column 10, line 58 to column 11, line 12, The signal inputted to VLD 308 is the signal.)

-- means for displaying the decoded image signal. (column 9, lines 33-57)

However, Ng does not teach (1) the filtering steps (MVPF) and (2) using the second motion vectors only for generating prediction errors.

The de Haan paper teaches filtering steps comprising:

-- filtering (MVPF) every occurrence of the first motion vectors (MVc, MV*l*, MVr, MVa, MVb) to obtain second motion vectors (MV1, MV2, MV3, MV4) for second objects, the second objects being smaller than the first objects (1/4 of the first object); (section VII in pages 373-374)

- providing x and y motion vector components of a given macroblock (MVc) and of macroblocks (MV*l*, MVr, MVa, MVb) adjacent to the given macroblock (MVc); (section VII in pages 373-374; Eq. (33))

- supplying for each block (MV1) of a number of blocks (MV 1, MV 2, MV 3, MV 4) corresponding to the given macroblock (MVc), x and y motion vector components respectively selected from the x and y motion vector components of the given macroblock (MVc) and from the x and y motion vector components of two blocks (MV*l*, MVa) adjacent to the block (MV1). (section VII in pages 373-374; Eq. (33); Fig. 7)

-- using only the obtained second motion vectors (MV1, MV2, MV3, MV4) of the second objects, not the motion vectors of the second objects, for motion compensation to reduce visible block structures. (first paragraph in section VII)

To be pointed out below, it would have been obvious to one of ordinary skill in the art to combine de Haan's and Ng's teachings. Because the Ng's decoding process is a reverse process of its own coding process, based on the combination, it would be obvious to one of ordinary skill in the art, at the time of the invention, in the decoding process to add the following feature already discussed above to implement the decoding process:

-- filtering every occurrence of the first motion vectors (MV c, MV l, MV r, MV a, MV b) using a set of motion vectors including the first motion vectors to obtain second motion vectors (MV 1, MV 2, MV 3, MV 4) for second objects, the second objects being smaller than the first objects.

Because the filtering process is for the purpose for reducing visible block structures with block erosion, the filtering is applied to every occurrence of the first motion vectors and only the filtered motion vectors of the smaller blocks are used for motion compensation.

It is desirable to reduce visible block structures in coding and decoding an image signal. It would have been obvious to one of ordinary skill in the art, at the time of the invention, to add de Haan's filtering processes for motion vectors in Ng's method and system because the combination provides a better quality of decoded images by reducing blockness.

***(11) Response to Argument***

a. Appellants' argument -- Ng in view of Haan et al. neither teaches nor suggests limitation A of " filtering (MVPF) every occurrence of the first motion vectors (MVc, MV*l*, MVr, MVa, MVb) to obtain second motion vectors (MV1, MV2, MV3, MV4) for second objects (8*8)." The section VII, pages 373-374 of de Haan neither teaches nor suggests limitation A. The Appellants specifically pointed to the following passage (page 373, right column, lines 2-9 of de Haan et al.) to support their point: "the block sizes commonly used in block matching are in a range that give rise to very visible artifacts ... Therefore, a post operation is introduced in this section: it eliminates fixed block boundaries from the vector field without blurring contours." The Appellants did not see what the part after page 373, right column, line 9 has to do with the presently recited "filtering." The Appellants alleged that this cited passage specifically fails to teach limitation A. The logic is not clear.

Examiner's response -- The cited passages in section VII, pages 373-374 of de Haan indeed teach the above limitation A.

First, de Haan points out that limiting to one vector per block of pixels introduces visible block structures with very visible artifacts (from the last two line, left column to line 3, right column, page 373.) This is a problem needed to be fixed.

Second, de Haan points out that the post filter in reference 15 can solve the problem. However, it introduces a drawback of blurring the discontinuities in the vector field (lines 3-6, right column, page 373.) A person skilled in the art understands that the discontinuities in the vector field are associated with contours. Blurring the discontinuities thus blurs the contours that are desired to be preserved for reproducing lines or sharp edges of objects in images.

Then, de Haan teaches a post-operation to solve the above problem without the above drawback (from line 7, right column, page 373 to the end of section VII in page 374.) In the post-operation, when one vector per block is available, the block $B(\underline{X})$ is divided into four sub-blocks $B_{-1,-1}(\underline{X})$, $B_{-1,1}(\underline{X})$, $B_{1,-1}(\underline{X})$, and $B_{1,1}(\underline{X})$ (shown in Equations 29-30 and Fig. 7) As defined in Equation 4 in page 369, $\underline{X}$ is the coordinates of the center of the block and is used for labeling the block. A new vector $D_{i,j}$ is assigned to each of the sub-blocks according to the med function defined in Eq. 33, where i and j take the values +1 or -1. (shown in Equations 31-33.)

In Equation 32, de Haan teaches that:

-- $\underline{D}(\underline{X}, t)$ is the vector of the central block $\underline{B}(\underline{X})$ at time t.

-- $\underline{D}(\underline{X} + (-1) \begin{pmatrix}X\\0\end{pmatrix}, t)$ is the vector of the left block $\underline{B}(\underline{X} + (-1) \begin{pmatrix}X\\0\end{pmatrix})$ at time t.

-- $\underline{D}(\underline{X} + (+1) \begin{pmatrix}X\\0\end{pmatrix}, t)$ is the vector of the right block $\underline{B}(\underline{X} + (+1) \begin{pmatrix}X\\0\end{pmatrix})$ at time t.

-- $\underline{D}(\underline{X} + (+1) \begin{pmatrix}0\\Y\end{pmatrix}, t)$ is the vector of the top block $\underline{B}(\underline{X} + (+1) \begin{pmatrix}0\\Y\end{pmatrix})$ at time t.

-- $\underline{D}(\underline{X} + (-1) \begin{pmatrix}0\\Y\end{pmatrix}, t)$ is the vector of the bottom block $\underline{B}(\underline{X} + (-1) \begin{pmatrix}0\\Y\end{pmatrix})$ at time t.

Let us explicitly write out one example for equation 32. For i = -1 and j = +1,

$$\underline{D}_{-1,1}(\underline{X}, t) = \underline{\text{med}}\left[\underline{D}(\underline{X} + (-1) \begin{pmatrix}X\\0\end{pmatrix}, t), \underline{D}(\underline{X}, t), \underline{D}(\underline{X} + (+1) \begin{pmatrix}0\\Y\end{pmatrix}, t)\right]$$

$$= \text{median}\left[\underline{D}(\underline{X} + (-1) \begin{pmatrix}X\\0\end{pmatrix}, t), \underline{D}(\underline{X}, t), \underline{D}(\underline{X} + (+1) \begin{pmatrix}0\\Y\end{pmatrix}, t)\right] \quad \text{-- } \mathbf{Eq.\ (a)}$$

$\underline{D}_{-1,1}(\underline{X}, t)$ of the left-up sub-block is assigned the median of the vectors of left, central, and top blocks. $\underline{D}_{1,1}(\underline{X}, t)$, $\underline{D}_{-1,-1}(\underline{X}, t)$, and $\underline{D}_{1,-1}(\underline{X}, t)$ are similarly assigned.

**The term "median" is defined as "*Statistics.* Pertaining to or constituting the middle value in a distribution" as shown in the attached copy of page 737 of Webster's II New Riverside University Dictionary. Therefore, $\underline{D}_{-1,1}(\underline{X}, t)$ is assigned the *middle value* of the set $\underline{D}(\underline{X} + (-1) \begin{pmatrix}X\\0\end{pmatrix}, t)$, $\underline{D}(\underline{X}, t)$, and $\underline{D}(\underline{X} + (+1) \begin{pmatrix}0\\Y\end{pmatrix}, t)$.**

(i) Based on the above explanation, de Haan indeed teaches the "filtering" recited in Claim 1 of the present application, because the process defined by Eq. (a) above is a filtering process. **A person skilled in the art knew at the time of the invention that the process defined by Eq. (a) shown in lines 15-16, page 7 of the present Examiner's Answer above is called "median filtering."**

**Evidence to confirm this fact is shown in the attached copy of page 191 of the book "Digital Image Processing," Gonzalez et al, 1993.**

**-- Page 191 of the book defines a median filtering as follows. The level of each pixel is replaced with the median of the levels in a neighbor of that pixel. The median value *m* of a set of values is such that half the values in the set are less than *m* and half are greater than *m*.**

**As pointed out above in page 7, when the med function defined by Eq.(a) is applied to the set of [$\underline{D}(\underline{X} + (-1)\binom{X}{0}, t)$, $\underline{D}(\underline{X}, t)$, and $\underline{D}(\underline{X} + (+1)\binom{0}{Y}, t)$], it generates the middle value of the set. The middle value thus has half the values in the set less than it and half greater than it. Accordingly, the med function indeed performs median filtering.**

Therefore, the paper of de Haan clearly teaches "median filtering every occurrence of the first motion vectors [$\underline{D}(\underline{X}, t)$, $\underline{D}(\underline{X} + (-1)\binom{X}{0}, t)$, $\underline{D}(\underline{X} + (+1)\binom{X}{0}, t)$, $\underline{D}(\underline{X} + (+1)\binom{0}{Y}, t)$, $\underline{D}(\underline{X} + (-1)\binom{0}{Y}, t)$] of the first blocks to obtain second motion vectors ($\underline{D}_{-1,1}(\underline{X}, t)$, $\underline{D}_{1,1}(\underline{X}, t)$, $\underline{D}_{-1,-1}(\underline{X}, t)$, $\underline{D}_{1,-1}(\underline{X}, t)$) for the second blocks, wherein the second blocks are 1/4 of the first blocks and thus smaller than the first blocks.

(ii) The fact that the filtering process of de Haan is the same as the "filtering" recited in Claim 1 of the present application is even more evident when we compare the above explanation

of de Haan with the filtering process disclosed by the Appellants in the section from line 32, page 3 to line 24 of page 4 of the present application.

When one makes this comparison, one will find the followings:

-- $\underline{D}(\underline{X}, t)$ of de Haan is the vector of the central block $\underline{B}(\underline{X})$ and thus teaches MVc of the present application.

-- $\underline{D}(\underline{X} + (-1)\binom{X}{0}, t)$ of de Haan is the vector of the left block $\underline{B}(\underline{X} + (-1)\binom{X}{0})$ and thus teaches MV*l* of the present application.

-- $\underline{D}(\underline{X} + (+1)\binom{X}{0}, t)$ of de Haan is the vector of the right block $\underline{B}(\underline{X} + (+1)\binom{X}{0})$ and thus teaches MVr of the present application.

-- $\underline{D}(\underline{X} + (+1)\binom{0}{Y}, t)$ of de Haan is the vector of the top block $\underline{B}(\underline{X} + (+1)\binom{0}{Y})$ and thus teaches MVa of the present application.

-- $\underline{D}(\underline{X} + (-1)\binom{0}{Y}, t)$ of de Haan is the vector of the bottom block $\underline{B}(\underline{X} + (-1)\binom{0}{Y})$ and thus teaches MVb of the present application.

The paper of de Haan further teaches that the motion vector $\underline{D}_{-1,1}(\underline{X}, t)$ of the upper-left sub-block, that corresponds to MV1 defined in Fig. 3 of the present application, is given by

$$\underline{D}_{-1,1}(\underline{X}, t) = \underline{\text{med}}\,[\underline{D}(\underline{X} + (-1)\binom{X}{0}, t), \underline{D}(\underline{X}, t), \underline{D}(\underline{X} + (+1)\binom{0}{Y}, t))$$

$$= \text{median}\,[\underline{D}(\underline{X} + (-1)\binom{X}{0}, t), \underline{D}(\underline{X}, t), \underline{D}(\underline{X} + (+1)\binom{0}{Y}, t)).$$

**With substituting definitions of the various motion vectors of de Haan with those of the present application, we find that de Haan indeed teaches**

**$\underline{\text{MV1}}(\underline{X})$ = median [MV*l*, MVc, MVa] -- the exact formula disclosed in page 4 of the present application.**

**The derivation of MV2, MV3, and MV4 is similarly taught by de Haan.**

**Therefore, the paper of de Haan clearly teaches "filtering every occurrence of the first motion vectors [MVc, MV*l*, MVr, MVa, MVb] of the first blocks to obtain second motion vectors (MV1, MV2, MV3, MV4) for the second blocks, wherein the second blocks are 1/4 of the first blocks and thus smaller than the first blocks.**

**It is desirable to reduce visible block structures in coding and decoding an image. As pointed out above, de Haan's method can reduce visible block structures without blurring contours. This provides an excellent motivation to incorporate de Haan's teaching of generating motion vectors for sub-blocks for motion compensation in Ng's MPEG video coding and decoding process.**

In Ng's patent, the blocks used for determining motion vectors are of size 16*16 and the coding is performed in block of size 8*8 using the same motion vector derived from 16*16 blocks for each sub-block. The combination of Ng and de Haan thus teaches division of blocks of size 16*16 to 4 sub-blocks of size 8*8 for determining better individual motion vector for each sub-block for motion compensation. Therefore, Ng in view of de Haan indeed teaches the above-mentioned limitation A and every feature recited in Claim 1.

b. Appellants' argument -- Ng in view of de Haan et al. neither teaches nor suggests limitation B of "generating prediction errors in dependence on said second motion vectors only."

Examiner's response -- Ng teaches "generating prediction errors in dependent on the motion vectors associated with the second objects (8*8) being smaller than the first objects (column 5, lines 39-64.) **The residues are the prediction errors.** They are generated with motion compensation in dependent on the motion vectors associated with second objects of size 8*8 only. However, in Ng's case, the motion vectors associated with second objects of size 8*8

are all the same as the motion vectors associated with their corresponding first objects of size 16*16. They are not the motion vectors generated through a filtering process as required in Claim 1. Using of different motion vectors for each second objects of size 8*8 is taught by de Haan as explained above in section 11(a).

The first paragraph of section VII of de Haan also teaches motion compensation for image coding. When Ng and de Haan are combined to achieve the advantage stated in section (10), it would have been obvious to one of ordinary skill in the art, at the time of the invention to use the motion vectors of the second objects derived through a filtering process taught by de Haan to generate the residues taught by Ng, because if one still uses the motion vectors of the original large blocks for motion compensation, visible block structure will appear as pointed out by de Haan as explained above. Therefore, the combination of Ng and de Haan indeed teaches "generating prediction errors in dependence on said second motion vectors only."

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

Wenpeng Chen
Primary Examiner
Art Unit 2624

October 30, 2002

Conferees
David Moore
Timothy Johnson

DAVID MOORE
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 2600

CORPORATE PATENT COUNSEL
U.S. PHILIPS CORPORATION
580 WHITE PLAINS ROAD
TARRYTOWN, NY 10591

# WEBSTER'S II
# New Riverside University Dictionary

pJ4737



e of several diseases displaying similar bu
rman measles. 2. A disease of cattle and
m larvae. 3. A plant disease usu. caused by
ute spots on stems and leaves.
*adj.* **-sli·er, -sli·est.** 1. Infected or spotted
2. *Slang.* Odiously small : MEAGER.
mĕzh'ər-ə-bəl) *adj.* 1. Able to be measured
rtance : SIGNIFICANT. 3. Not so great as to
measure : MODERATE. **—meas'ur·a·bil**
*adv.*
'ər) *n.* [ME < OFr. *mesure* < Lat. *mensura*
. Dimensions, capacity, or quantity as deter
reference sample or standard used for the
of properties. 3. A unit specified by a scale
le conditions, as a day's march. 4. A syst
he metric system. 5. A device, as a marked
iner, used for measuring. 6. An act of mea
f comparison : CRITERION <"the final meas
ciety" —Joseph Wood Krutch> 8. The degre
ng. 9. A fitting amount <a *measure* of app
ed degree or amount. 11. Limit : bounds <
sure> 12. Appropriate restraint : MODERA
*asure*> 13. *often* **measures.** An action taken
: EXPEDIENT. 14. A legislative bill or enact
.6. *Mus.* The metric unit between two bars
**ured, -ur·ing, -ures.** —*vt.* 1. To determi
ity, or capacity of. 2. To mark, establish, or
measuring. 3. To estimate by comparison or
:m an account . . . of the situation as far as
inston Churchill> 4. To bring into oppo
ower with the adversary> 5. To mark off
a given unit of measurement <*measure* ou
rve as a measure of <An altimeter *measur*
ribute or allot as if by measuring : METE
ut severe sentences.> 8. To choose or
t <*measure* one's words> 9. *Archaic.* To
*measure* much ground today" —Shakes
measurement of <The kitchen *measures* 1
' of measurement. **—beyond measure.** 1
imit. **—for good measure.** In addition
**—in a** (*or* **some**) **measure.** To a degree
*ne measure* faulty.> **—measure up.** 1. To
ve the necessary qualifications. **—meas'ur**
h'ərd) *adj.* 1. Determined by measurement
distance> 2. Regular, as in number and
: slowly in the house with a *measured*
s Wolfe> 3. Careful : restrained. 4. Calc
arcasm> 5. Slow and stately. 6. Metrical
ited <a *measured* capacity for crea
*dv.* **—meas'ured·ness** *n.*
(mĕzh'ər-lĭs) *adj.* Without limits :
**ly** *adv.*
**t** (mĕzh'ər-mənt) *n.* 1. The act of measu
easured. 2. A system of measuring. 3. The
quantity determined by measuring.
**rm** *n.* A geometrid caterpillar that moves
and expansions suggestive of measuring.
E *mete* < OE, food.] 1. The edible flesh
fleshy, inner part <lobster *meat*> 3. Th
uts, or fruits. 4. The essence or central
> 5. *Slang.* Something one enjoys or
ng eaten for nourishment : FOOD.
The word *meat* is an example of a wo
ecome narrower in the course of its dev
es the word denoted food of any kind, b
rast to liquids. This is the sense of *meat*
*eetmeat,* "a piece of candy," and *nutm*
t." In later medieval times *meat* came to
ntrast to fish, and at times in contrast to
it times *meat* has occasionally been re
lar kind of animal flesh, such as pork.
**bôl')** *n.* 1. A small ball of cooked, often
ang. A stupid, awkward, or dull person.
**ls)** *adj.* 1. Lacking meat or food. 2. Bein
a meat is not to be eaten, as for religious
usu. loaf-shaped baked dish of seasoned
**əs)** *n., pl.* **-tus·es** *or* **meatus.** [Lat.,
body canal or passage, as the opening of th
*adj.* **-i·er, -i·est.** 1. **a.** Of or relating
ll or flavor of meat. **c.** Full of or containi
3. Amply thought-provoking <a *meaty*
**at'i·ness** *n.*

**ă**re ā father ĕ pet ē be hw wh
pot ō toe ô paw, for oi noise

**[mec]a·myl·a·mine** (mĕk'ə-mĭl'ə-mēn') *n.* [Orig. a trademark.] A $C_{11}H_{21}N \cdot HCl$, administered orally to reduce highly elevated [blood] pressure.
**[Mec]·ca** (mĕk'ə) *n.* [After *Mecca,* Saudi Arabia, from its being a [center] of pilgrimage.] 1. **a.** A place held to be the center of an activity [or] interest. **b.** A goal to which adherents of a religious faith or prac[tice] fervently aspire. 2. A place visited by many people <a tourist [mecca]>
**[mech]an-** *pref. var. of* MECHANO-.
**[me·ch]an·ic** (mĭ-kăn'ĭk) *n.* [< ME, mechanical < OFr. *mecanique* < [Lat.] *mechanicus* < Gk. *mēkhanikos* < *mēkhanē,* machine < *mēkhos,* [means.]] A worker skilled in using, making, or repairing machines [and] tools. **—me·chan'ic** *adj.*
**[me·c]han·i·cal** (mĭ-kăn'ĭ-kəl) *adj.* [ME < *mechanic,* mechanical. —see] MECHANIC.] 1. Of or relating to machines or tools. 2. Operated [or pro]duced by a machine. 3. Of, relating to, or governed by mechan[ics.] 4. Performing or acting like a machine : AUTOMATIC <an insin[cere,] mechanical greeting> 5. Relating to, produced by, or [domin]ated by physical forces. 6. Interpreting and explaining the phe[nomena] of the universe by referring to causally determined material [forces] : MECHANISTIC. 7. Of or relating to manual labor, its tools, and [its] skills. —*n.* A layout of type proofs, artwork, or both, exactly posi[tioned] and prepared for making a printing plate, as an offset. **—me·[chan']i·cal·ly** *adv.* **—me·chan'i·cal·ness** *n.*
**[me]chanical advantage** *n.* The ratio of the output force of a [ma]chine to the input force.
**[me]chanical drawing** *n.* 1. Drafting. 2. A drawing, as an archi[tect']s plans, that enables measurements to be interpreted.
**[me]chanical engineering** *n.* The branch of engineering that [encom]passes the generation and application of heat and mechanical [power] and the production, design, and use of machines and tools. **—[me]chanical engineer** *n.*
**[mech]·a·ni·cian** (mĕk'ə-nĭsh'ən) *n.* One who uses, makes, or re[pairs] machines and tools.
**[me·c]han·ics** (mĭ-kăn'ĭks) *n.* (*sing. or pl. in number*). 1. Analysis [of] the action of forces on matter or material systems. 2. Design, op[eration,] construction, and application of machinery or mechanical [struc]tures. 3. The technical and functional aspects of an activity [<th]e *mechanics* of baseball>
**[me]ch'a·nism** (mĕk'ə-nĭz'əm) *n.* [LLat. *mechanisma* < Gk. *mē*[*khanē,*] machine. —see MECHANIC.] 1. **a.** A mechanical device : MA[CHINE.] **b.** Arrangement of machine parts. 2. A system of parts that [interact] or operate like those of a machine <the *mechanism* of the [world]> 3. A physical instrument or process by which something is [done] or originates <"The *mechanism* of oral learning is largely that [of] continuous repetition" —T.G.E. Powell> 4. *Psychol.* **a.** Automa[tic] and consistent response of an organism to various stimuli. **b.** A [habitual] manner of acting to achieve an end. 5. *Psychoanal.* A usu. [uncon]scious mental and emotional pattern that dominates behavior. [6. *Chem.*] The sequence of steps in a chemical reaction. 7. *Philos.* [The] doctrine that all natural phenomena are explainable by material [causes] and mechanical principles.
**[me]ch'a·nist** (mĕk'ə-nĭst) *n.* 1. One who adheres to the philosophi[cal] doctrine of mechanism. 2. A mechanician.
**[mech']a·nis·tic** (mĕk'ə-nĭs'tĭk) *adj.* 1. Mechanically determined. [2.] Of or relating to mechanism, esp. tending to explain phe[nomena] only by reference to physical or biological causes. 3. Me[chanic]al. **—mech'a·nis'ti·cal·ly** *adv.*
**[mech']a·nize** (mĕk'ə-nīz') *vt.* **-nized, -niz·ing, -niz·es.** 1. To [equip] with machinery. 2. To equip (a military unit) with motor ve[hicles,] tanks and trucks. 3. To make automatic or unspontaneous. [4. To pro]duce by or as if by machines. **—mech'a·ni·za'tion** *n.* **—[mech']a·niz'er** *n.*
**[mech']ano-** *or* **mechan-** *pref.* [ME *mechan-* < Lat. < Gk. *mē*[*khan-* <] *mēkhanē,* machine.] 1. Machine : machinery <*mecha*[*nize*>] [2.] Mechanical <*mechano*therapy>
**[mech']a·no·chem·i·cal coupling** (mĕk'ə-nō-kĕm'ĭ-kəl) *n.* Re[versible] conversion of chemical energy into mechanical work.
**[mech']a·no·re·cep·tor** (mĕk'ə-nō-rĭ-sĕp'tər) *n.* A receptor that re[sponds] to mechanical stimuli, as tension and pressure. **—mech'a·[no·re·cep']tion** *n.* **—mech'a·no·re·cep'tive** *adj.*
**[mech']a·no·ther·a·py** (mĕk'ə-nō-thĕr'ə-pē) *n.* Medical treatment [by mechanical] methods, as massage. **—mech'an·o·ther'a·pist** *n.*
**[Mech]·lin** (mĕk'lĭn) *n.* [After *Mechlin,* Belgium.] Lace in which [the patt]ern details are defined by a flat thread.
**[me·co]·ni·um** (mĭ-kō'nē-əm) *n.* [Lat. < Gk. *mēkōneion* < *mēkōn,* [poppy.] Excrement in the fetal intestinal tract discharged at birth.
**[me·cop]·ter·an** (mĭ-kŏp'tər-ən) *n.* [< NLat. *Mecoptera,* order [name <] Gk. *mēkos,* length + Gk. *pteron,* wing.] One of various [carnivor]ous insects of the order Mecoptera, distinguished by an elon[gated head] similar to a beak with chewing mouthparts at the tip.
**[me·da]·ka** (mĭ-dä'kə) *n.* [J., killifish.] 1. The Japanese rice fish, [esp. stri]pes, used in biological research. 2. A fish of the Asiatic [and] Malayan genus *Oryzias.*

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**med·al** (mĕd'l) *n.* [Fr. *médaille* < OItal. *medaglia,* coin worth half a denarius, medal < VLat. **medalis* < LLat. *medialis,* middle < Lat. *medius.*] 1. A flat piece of metal stamped with a commemorative design or inscription, often presented as an award. 2. A piece of metal stamped with a religious symbol, used as an object of worship or commemoration.
**Medal for Merit** *n.* A decoration awarded by the United States to civilians for outstanding services in war or peace.
**med·al·ist** (mĕd'l-ĭst) *n.* 1. One who makes, designs, or collects medals. 2. A recipient of a medal.
**me·dal·lion** (mĭ-dăl'yən) *n.* [Fr. *médaillon* < Ital. *medaglione,* aug. of *medaglia,* medal < OItal. —see MEDAL.] 1. A large medal. 2. One of various large ancient Greek coins. 3. Something like a large medal.
**med·al·list** (mĕd'l-ĭst) *n. Chiefly Brit. var. of* MEDALIST.
**Medal of Freedom** *n.* A decoration awarded by the United States to civilians for outstanding achievement in various fields of endeavor.
**Medal of Honor** *n.* The highest U.S. military decoration, awarded by Congress to military personnel for gallantry and bravery beyond the call of duty in action against an enemy.
**med·dle** (mĕd'l) *vi.* **-dled, -dling, -dles.** [ME *medlen* < OFr. *medler,* var. of *mesler* < VLat. **misculare,* freq. of Lat. *miscēre,* to mix.] 1. To intrude in other people's business or affairs : INTERFERE. 2. To handle something ignorantly or idly : TAMPER. **—med'dler** (mĕd'lər, mĕd'l-ər) *n.*
**med·dle·some** (mĕd'l-səm) *adj.* Inclined to meddle. **—med'dle·some·ly** *adv.* **—med'dle·some·ness** *n.*
**Me·de·a** (mĭ-dē'ə) *n.* [Lat. < Gk. *Mēdeia.*] *Gk. Myth.* A princess and sorceress of Colchis who helped Jason obtain the Golden Fleece.
**Med·fly** *also* **med·fly** (mĕd'flī') *n.* The Mediterranean fruit fly.
**me·di·a**[1] (mē'dē-ə) *n. var. pl. of* MEDIUM.
**me·di·a**[2] (mē'dē-ə) *n.* MEDIAL 1.
**me·di·a·cy** (mē'dē-ə-sē) *n.* 1. The quality or state of being mediate. 2. Mediation.
**me·di·ae·val** (mē'dē-ē'vəl, mĕd-ē'-) *adj. var. of* MEDIEVAL.
**me·di·ae·val·ism** (mē'dē-ē'və-lĭz'əm, mĕd-ē'-) *n. var. of* MEDIEVALISM.
**me·di·ae·val·ist** (mē'dē-ē'və-lĭst, mĕd-ē'-) *n. var. of* MEDIEVALIST.
**media event** *n.* An occasion that is orchestrated and publicized so as to achieve wide coverage by the print and electronic media <turned an otherwise dull press conference into a *media event*>
**me·di·al** (mē'dē-əl) *adj.* [LLat. *medialis* < Lat. *medius,* middle.] 1. Relating to, situated in, or extending toward the middle : MEDIAN. 2. Being a sound, syllable, or letter occurring between the initial and final positions in a word or morpheme. 3. Being or relating to a mathematical mean or average. 4. Ordinary : average. —*n.* 1. A voiced stop, as *b, d,* or *g.* 2. An element, as a sound, letter, or form of a letter, used in the middle of a word. **—me'di·al·ly** *adv.*
**me·di·an** (mē'dē-ən) *adj.* [Lat. *medianus* < *medius,* middle.] 1. Relating to, situated in, or directed toward the middle : MEDIAL. 2. *Anat. & Zool.* Of, relating to, or lying in the plane that divides a bilaterally symmetric animal into right and left halves : MESIAL. 3. *Statistics.* Pertaining to or constituting the middle value in a distribution. —*n.* 1. A median point, line, plane, or part. 2. *Statistics.* The middle value in a distribution, above and below which lie an equal number of values. 3. *Math.* **a.** A line that joins a vertex of a triangle to the midpoint of the opposite side. **b.** The line that joins the midpoints of the nonparallel sides of a trapezoid. **—me'di·an·ly** *adv.*
**median plane** *n.* A plane dividing a bilaterally symmetric animal into right and left halves.
**median point** *n.* The intersection of the medians of a triangle.
**median strip** *n.* The dividing area, either landscaped or paved, between opposing highway traffic lanes.
**me·di·ant** (mē'dē-ənt) *n. Mus.* The third tone in a diatonic scale between the tonic and the dominant and related harmonically to them.
**me·di·as·ti·na** (mē'dē-ə-stī'nə) *n. pl. of* MEDIASTINUM.
**me·di·as·ti·ni·tis** (mē'dē-ăs'tə-nī'tĭs) *n.* Inflammation of the mediastinum.
**me·di·as·ti·num** (mē'dē-ə-stī'nəm) *n., pl.* **-na** (-nə) [NLat. < Med. Lat. *mediastinus,* medial < Lat., drudge < *medius,* middle.] The septum that divides the pleural sacs in mammals, containing all the thoracic viscera except the lungs. **—me'di·as·ti'nal** *adj.*
**me·di·ate** (mē'dē-āt') *v.* **-at·ed, -at·ing, -ates.** [LLat. *mediare, mediat-,* to be in the middle < Lat. *medius,* middle.] —*vt.* 1. To settle or resolve (differences) by acting as an intermediary between two or more opposing parties. 2. To bring about (e.g., a settlement) by action as an intermediary. 3. To transmit or convey as an intermediary agent or mechanism. —*vi.* 1. To intervene between two or more disputing parties in order to effect a settlement, agreement, or compromise. 2. To reconcile differences. —*adj.* (mē'dē-ĭt). Acting through, involving, or dependent on an intervening agency. **—me'di·ate·ly** (-ĭt-lē) *adv.*
**me·di·a·tion** (mē'dē-ā'shən) *n.* 1. The act of mediating or state of being mediated. 2. *Law.* An attempt to effect a peaceful settlement or compromise between disputing nations through the benevolent intervention of a neutral power. **—me'di·a'tive, me'di·a·to'ry** *adj.*

**Library of Congress Cataloging-in-Publication Data**

Gonzalez, Rafael C.
Digital image processing / by Rafael C. Gonzalez, Richard E. Woods.
p. cm.
Includes bibliographical references and index.
ISBN 0-201-50803-6
1. Image processing—Digital techniques. I. Woods, Richard E.
II. Title.
TA1632.G66 1992
621.36'7—dc20 91-3086
CIP

**Reprinted with corrections September, 1993**



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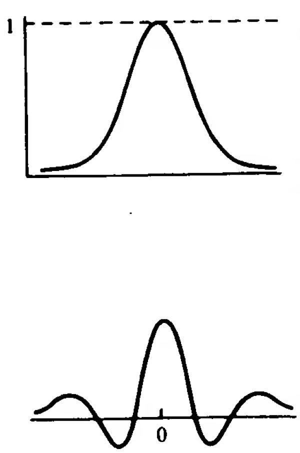

(c)

*rly symmetric frequency domain*
*ıin filters.*



reduction can be achieved effectively with a nonlinear filter whose basic function is to compute the median gray-level value in the neighborhood in which the filter is located. Other examples include the *max* filter (with a response $R = \max\{z_k \mid k = 1, 2, \ldots, 9\}$), which is used to find the brightest points in an image, and the *min* filter, which is used for the opposite purpose.

### 4.3.2 Smoothing Filters

Smoothing filters are used for blurring and for noise reduction. Blurring is used in preprocessing steps, such as removal of small details from an image prior to (large) object extraction, and bridging of small gaps in lines or curves. Noise reduction can be accomplished by blurring with a linear filter and also by nonlinear filtering.

**Lowpass spatial filtering**

The shape of the impulse response needed to implement a lowpass (smoothing) spatial filter indicates that the filter has to have all positive coefficients (see Fig. 4.19a). Although the spatial filter shape shown in Fig. 4.19(a) could be modeled by, say, a sampled Gaussian function, the key requirement is that all the coefficients be positive. For a $3 \times 3$ spatial filter, the simplest arrangement would be a mask in which all coefficients have a value of 1. However, from Eq. (4.3-1), the response would then be the sum of gray levels for nine pixels, which could cause $R$ to be out of the valid gray-level range. The solution is to scale the sum by dividing $R$ by 9. Figure 4.21(a) shows the resulting mask. Larger masks follow the same concept, as Figs. 4.21(b) and (c) show. Note that, in all these cases, the response $R$ would simply be the average of all the pixels in the area of the mask. For this reason, the use of masks of the form shown in Fig. 4.21 is often referred to as *neighborhood averaging*. Figure 4.22 shows an example of blurring by successively larger smoothing masks. Note in particular the loss of sharpness in the filament of the bulb as the smoothing mask becomes larger.

**Median filtering**

One of the principal difficulties of the smoothing method discussed in the preceding section is that it blurs edges and other sharp details. If the objective is to achieve noise reduction rather than blurring, an alternative approach is to use *median filters*. That is, the gray level of each pixel is replaced by the median of the gray levels in a neighborhood of that pixel, instead of by the average. This method is particularly effective when the noise pattern consists of strong, spikelike components and the characteristic to be preserved is edge sharpness. As indicated earlier, median filters are nonlinear.

The median $m$ of a set of values is such that half the values in the set are less than $m$ and half are greater than $m$. In order to perform median filtering in a neighborhood of a pixel, we first sort the values of the pixel and its neighbors, determine the median, and assign this value to the pixel. For example,